Coastal Ocean Optical Properties in Santa Barbara Basin: Blooms & Plumes

Raymond C. Smith
Institute for Computational Earth System Science (ICESS)
University of California at Santa Barbara
Santa Barbara, CA 93106-3060
phone: 805-893-4709 fax: 805-893-2578 email: ray@icess.ucsb.edu

Co-PIs (all at the University of California at Santa Barbara):

Mark Brzezinski
Department of Ecology, Evolution, and Marine Biology
phone: 805-893-8605 fax: 805-893-8062 email: brzezins@lifesci.ucsb.edu

Leal Mertes
Department of Geography
phone: 805-893-7017 fax: 805-893-3146 email: leal@geog.ucsb.edu

Dave Siegel
ICESS
phone: 805-893-4547 fax: 805-893-2578 email: davey@icess.ucsb.edu

Libe Washburn
ICESS
phone: 805-893-7367 fax: 805-893-2578 email: washburn@icess.ucsb.edu

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RESEARCH GOALS

Our primary goals are 1.) to accurately model the optical properties of Case II waters in order to estimate the respective contributions and fluxes of biogenic and terrigenous material, and 2.) to develop algorithms for the optical characteristics of Case II waters for comparison and testing with the recently launched SeaWiFS satellite.

OBJECTIVES

This work is closely linked to other ONR and NOAA-funded research in Santa Barbara Basin with the objective of this work primarily focused on the mooring observations. Our objectives are to:

1. obtain a multi-platform (ship, mooring, and satellite) time series record of the spatial and temporal variability of sediment-producing processes within the Santa Barbara Basin (SBB) to provide input data for our models,

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2. link the in situ bio-optical data to contemporaneous SeaWiFS satellite data to construct an appropriate data base for Case II ocean color algorithm development,

3. refine existing algorithms for estimation of surface pigment concentrations (Chl-a) and, as appropriate, near-surface terrigenous material,

4. model these Case II waters in order to estimate both terrigenous and marine constituents and their respective fluxes for comparison with the high resolution sediment record from the SBB.

The time series and satellite data allow unprecedented space/time coverage and optical documentation of SBB Case II water types, providing a unique opportunity to develop and refine optical models. A further scientific objective is to utilize these data and the resultant models to quantitatively link surface processes with the SBB layered sediment record, which contains one of the most well-preserved and finely detailed climatic records in the world. The record permits biannual resolution and thus provides a direct link to the sediment-producing physical and biogeochemical processes in the waters above.

TECHNICAL APPROACH

Our approach is interdisciplinary, combining optical (Smith, Siegel), physical (Washburn, Siegel) and biological (Brzezinski, Smith) oceanography with a terrestrial (geomorphology and sediment supply, Mertes) component. We use a multiplatform sampling effort (Smith et al., 1987) to collect the bio-optical and relevant ancillary data necessary to model Case II waters. The focal point of our sampling strategy is the UCSB surface-to-bottom mooring. Two subsurface optical sensors (BSI MER-2020Us) at 5m and 15m collect downwelling irradiance and upwelling radiance measurements at SeaWiFs-equivalent wavelengths (410nm, 441nm, 488nm, 520nm, 565nm, and 765nm), and a surface unit measures downwelling irradiance at 410nm, 441nm, 488nm, and 560nm. The instruments sample every four minutes, yielding a detailed record of short-term diurnal variability in addition to longer-term seasonal change. The high sampling rate and extensive deployment allow an assessment of bio-optical changes over time scales from several minutes to about a year. Other mooring instrumentation includes a temperature/salinity probe and a recently added transmissometer. In addition, the mooring is equipped with a GPS-radio modem that provides "real-time" contact, relaying the mooring position and selected surface water properties at specific time intervals.

The continuous record collected by the mooring is consistently validated and augmented through bi-weekly shipboard sampling and extensive satellite imagery. Prior to mid-1996, relatively shallow (100m) CTD and optical profiling (PRR) casts were conducted at the mooring site from a 15' Boston Whaler. Since mid-1996 sampling has been conducted from a 56' NOAA vessel due to the establishment of a mutually beneficial relationship with the Channel Islands National marine Sanctuary (CINMS). The larger platform has enabled the program to extend the transect across the Channel, increase the number of sampling stations to seven, and routinely conduct CTD casts to 450m at the mooring.

The transect crosses the main circulation gyre patterns of the SBB and thus ensures a gradient of optical water types. Presently, a wide variety of optical, physical, and biological parameters are measured at each station, including OFFI-type profiles with PRR (SeaWiFS bandwidths plus PAR) and PUV (305, 320,340,380nm, plus PAR); CTD, beam-c and stimulated fluorescence profiles; full-spectral profiles from 350-700nm using an ASD instrument; surface downwelling irradiance and upwelling radiance at 7 SeaWiFS wavelengths using a TSRB; water column measurements of particulate carbon, particulate nitrogen, lithogenic (terrigenous) silica, biogenic silica, chl-a and nutrient (nitrate, phosphate, silicate) concentration; and measurement of total suspended particulate material (TSM).

The mooring and shipboard sampling program are complemented by acquisition and analysis of satellite imagery, using the UCSB Terascan system (AVHRR and SeaWiFS data) as well as higher resolution Landsat imagery. We currently receive multiple AVHRR passes each day; these data are invaluable in placing the mooring data within the broader space/time context of the complete basin and its adjoining waters. High resolution Landsat imagery has been acquired during and after storm events in order to track the subsequent sediment flow into the SBB. These images are essential for understanding the processes associated with terrigenous input to the system and its contribution to optically-active components in the water column.

Each of the bio-optical data sets (continuous mooring, periodic transects, and daily satellite imagery) is a valuable time series of bio-optical information. In addition to these time series observations, two process-oriented cruises are carried out each year (see below). Combined, this multiplatform data set provides a comprehensive picture of the spatial and temporal variability of the optical, physical, and biological characteristics of the Case II waters.

WORK COMPLETED

During the past year, moored optical instruments have been deployed continuously in the SBB. Data recovery rates for the three instruments (surface, 5m, and 15m) averaged between 80-95%. Optical profiling observations continued to be conducted on a twice monthly (Table 1) basis, deploying the instruments listed in the preceding section. In addition, two multi-day data collection cruises were conducted. The first was a focused Rprocess cruiseS, which specifically targeted a late winter rainstorm event and the subsequent influx of terrigenous material to the system. High-density optical, physical, chemical, and biological observations were collected over a 3-day period as the ship crisscrossed a plume gradient from the Santa Clara river mouth to clearer offshore waters. The second collection cruise began on October 21, when the use of the 175U NOAA Ship McArthur was obtained for an 8 day period. During that time an extensive series of optical measurements was conducted both at the standard Channel stations as well as at sites significantly west of the Channel in order to obtain open ocean water conditions. Three tow-yo CTD transects were also performed in an effort to track the existence of deep (200-500m) sediment layers which have intermittently appeared during normal time series observations.

The regular and intermittent cruise are briefly summarized as follows:

Table 1.

1997	Cruises (days)	CTD Casts	PRR Profiles	ASD Profiles	TSRB Profiles	Water Samples
Transect	20	88	92	92	92	1672
Process	4	27	26	26	0	1485
McArthur	8	29	29	29	29	551

SCIENTIFIC RESULTS

Examination of relationships between K and water mass types at the mooring shows upper-layer optical changes consistent with the variability of different water masses. In particular, K values increase from 0.2 m-1 to approximately 0.5 m-1 during January through June, the period of maximum sediment influx and phytoplankton growth. Analysis will focus on the link between these different optical signatures and the particular physical and biological characteristics of the water masses.

IMPACT/APPLICATION

Though relatively small in area, Case II waters are representative of the coastal waters of most nations and thus are of a significance disproportionate to their relative size. Coastal waters provide high biological production, offer key transportation and supply routes, and figure prominently in national security issues, making them among the most important waters of the world's oceans. Their optical properties are relatively poorly documented, understood, and modeled. Our goal of accurately modeling the optical properties of these waters will thus have both scientific value and important implications for optical sensor applications in these Case II waters.

TRANSITIONS

Our observations provide "real-time" estimates of terrigenous and biogenous flux to the sediment load, which will be compared with sediment cores from the SBB, thus providing a "direct link" between surface fluxes and deposition to the sea floor in an area where the paleo record permits biannual resolution. Our observations, in concert with those related projects (see below) provide local marine managers (CINMS) with long-term observations for assessing annual and interannual variability in the local marine ecosystem.

RELATED PROJECTS

Data are shared with researchers working under the NOAA-sponsored Coastal Ocean Program, in conjunction with the NOAA Channel Islands National Marine Sanctuary (CINMS) office, to determine the sources and causes of sediment plumes and phytoplankton blooms in the Santa Barbara Channel and their physical and bio-optical characteristics.

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